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VOLUME TABLES AND EQUATIONS FOR WHITE SPRUCE, BALSAM POPLAR, AND PAPER BIRCH OF THE KUSKOKWIM RIVER VALLEY, ALASKA

by

RONALD M. DIPPOLD, Associate Photogrammetrist

and

WILBUR A. FARR, Mensurationist

Institute of Northern Forestry

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ABSTRACT

Volume tables and equations were derived from a sample of trees from the Kuskokwim River valley. Cubic-foot tables were developed for white spruce, paper birch, and balsam poplar. Board-foot tables, International 1/4-inch and Scribner rules, were prepared for white spruce.

KEYWORDS: Volume tables, volume equations, white spruce, balsam poplar, paper birch, Kuskokwim River valley, Alaska.

INTRODUCTION

Analysis of data obtained during a preliminary timber reconnaissance in the Kuskokwim River valley in 1966 indicated the volume equations developed by Haack[1/] for interior Alaska did not apply to this area. Therefore, in 1967, when an inventory was made of the forest resources along the Kuskokwim River, 295 trees were felled and measured so that volume equations and tables could be developed. Volume equations and tables derived from these measurements are presented here.

The species sampled were white spruce (*Picea glauca* (Moench) Voss), balsam poplar (*Populus balsamifera* L.), and paper birch (*Betula papyrifera* Marsh.). Sample trees were selected by extending the standard forest inventory 10-point cluster[2/] to an 11th point. Commercial forest land and operable noncommercial forest land were sampled.[3/]

Up to three trees 5-inch diameter breast high (d.b.h.) or larger were systematically selected per point. Cull and obviously deformed trees were not included in the sample

The sample trees were felled and measured using procedures similar to those described by Haack.[4/] Diameter outside bark and double bark thickness were recorded at the 1-foot stump, d.b.h., 9.15 feet on the bole, and then at 8.15-foot intervals to a 4.0-inch diameter outside bark. Measurements were also taken where there were pronounced changes in diameter such as at forks. For spruce sawtimber trees, 9-inch d.b.h. or larger, and hardwood species, 11-inch d.b.h. or larger, measurements were also taken at the minimum saw-log diameter, 7-inch and 9-inch diameter outside bark, respectively.

[1/] Paul M. Haack, Jr. Volume tables for trees of interior Alaska. Juneau, USDA Forest Serv. Res. Note NOR-5, 11 p., 1963.

[2/] USDA Forest Service, FSH 4813.1 Forest Survey Handbook. p. 42.9--1, March 1967.

[3/] Sites capable of producing at least 20 cubic feet per acre per year are classified as commercial forest land by Forest Survey, and sites producing less, noncommercial. Noncommercial sites presently supporting 800 or more cubic feet per acre are considered operable noncommercial.

[4/] Paul M. Haack. Compilation of tree measurement data by hand or computer. Juneau, USDA Forest Serv. Northern Forest Exp. Sta., 17 p., 1964.

Smalian's formula was used to compute cubic-foot volume to a 4-inch diameter outside bark.

International 1/4-inch and Scribner rules were used to compute board-foot volumes for white spruce sawtimber trees from a 1-foot stump to a 7.0-inch diameter outside bark for 16.30-foot[5/] logs. Partial logs 8.15 feet to 16.30 feet long were treated as full logs. Partial log lengths shorter than 8.15 feet were given zero volume.

These same log rules were used to compute board-foot volumes for birch and poplar sawtimber trees from a 1-foot stump to a 9.0-inch diameter outside bark. Because the sample yielded only 11 birch and 20 poplar sawtimber trees, reliable board-foot volume equations or tables could not be developed. Analysis of the data, however, indicated paper birch in the Kuskokwim River valley has less volume and balsam poplar more volume for a given diameter (D) and total height (H) than reported by Haack[6/] for the interior of Alaska in general.

Regression analysis was used to develop the volume (V) equations. Equations tested were:

Weighted combined variable,

$$\frac{V}{D^2H} = \frac{b_0}{D^2H} + \frac{b_1}{DH} + \frac{b_2}{H} + \frac{b_3}{D^2} + b_4 + \frac{b_5}{D^4H}$$

Logarithmic combined variable,

$$\log V = \log b_0 + b_1 \log D^2H + b_2 (\log D^2H)^2$$

and the Schumacher logarithmic equation,

$$\log V = \log b_0 + b_1 \log D + b_2 \log H$$

Separate formulas were developed for each species, location (upper and lower Kuskokwim), and land use (commercial and noncommercial forest land) combination. Subsequent tests using analysis of covariance indicated that data from the upper and lower Kuskokwim and from commercial and noncommercial forest land could be pooled. Analysis of covariance also indicated that cubic-foot volume data for balsam poplar and paper birch could be pooled.

[5/] Includes 0.3-foot trim allowance.

[6/] See footnote 1.

Relative efficiency of weighted combined vs. the logarithmic regressions was determined in the manner suggested by Furnival.[7] In all cases, the weighted combined variable equation reduced to the form:

$$\frac{V}{D^2H} = \frac{b_0}{D^2H} + b_4$$

and this form of the equation proved more efficient than either of the logarithmic equations. Schumacher's logarithmic equation was second best in all cases.

The basic data used by Haack[8] to develop volume tables for interior Alaska were compared with these data by use of analysis of covariance. These tests showed a significant difference between equations for all species-volume combinations.

DISCUSSION

These equations and tables were developed for and used with the forest inventory of the Kuskokwim River valley. They may prove superior to other existing tables for use in other timber stands in western Alaska such as the lower Yukon, Koyukuk, and Kobuk River valleys, but no tests have been made to determine this.

The equations used and their precision are given in footnote 1 of each volume table.

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[7] G. M. Furnival. An index for comparing equations used in constructing volume tables. Forest Sci. 7: 337-341, 1961.

[8] See footnote 1.

Table 1.--*Cubic-foot volumes (1-foot stump to 4-inch top, d.o.b.), Smalian's formula, for white spruce, Kuskokwim River valley, Alaska*[1/]

D.b.h. (*D*) [2/]	Total height in feet (*H*)[3/]																	Basis: trees measured[4/]
	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	
Inches																		*Number*
5	1.2	1.4	1.7	2.0	2.2	2.5	2.8	3.0										5
6	1.9	2.3	2.6	3.0	3.4	3.8	4.2	4.6										11
7	2.7	3.2	3.7	4.3	4.8	5.3	5.8	6.3	6.9									12
8	3.7	4.3	5.0	5.7	6.4	7.1	7.7	8.4	9.1	9.8								16
9		5.6	6.5	7.3	8.2	9.0	9.9	10.8	11.6	12.5	13.3							18
10		7.0	8.1	9.1	10.2	11.2	12.3	13.4	14.4	15.5	16.5	17.6						14
11		8.6	9.9	11.1	12.4	13.7	15.0	16.3	17.5	18.8	20.1	21.4						15
12			11.8	13.3	14.9	16.4	17.9	19.4	21.0	22.5	24.0	25.5	27.1					14
13			13.9	15.7	17.5	19.3	21.1	22.9	24.7	26.5	28.2	30.0	31.8					11
14			16.2	18.3	20.4	22.4	24.5	26.6	28.7	30.8	32.8	34.9	37.0					8
15				21.1	23.4	25.8	28.2	30.6	33.0	35.4	37.7	40.1	42.5	44.9	47.3			6
16				24.0	26.7	29.4	32.2	34.9	37.6	40.3	43.0	45.7	48.4	51.1	53.9	56.6		11
17					30.2	33.3	36.3	39.4	42.5	45.5	48.6	51.7	54.7	57.8	60.9	63.9	67.0	8
18						37.4	40.8	44.2	47.7	51.1	54.5	58.0	61.4	64.8	68.3	71.7	75.1	6
19						41.7	45.5	49.3	53.2	57.0	60.8	64.6	68.5	72.3	76.1	79.9	83.8	5
20						46.2	50.5	54.7	58.9	63.2	67.4	71.7	75.9	80.1	84.4	88.6	92.9	3
21						51.0	55.7	60.4	65.0	69.7	74.4	79.1	83.7	88.4	93.1	97.7	102	1
22									71.4	76.5	81.7	86.8	91.9	97.1	102	107	112	1
23									78.1	83.7	89.3	94.9	101	106	112	117	123	--
24											97.3	103	109	116	122	128	134	1
25											106	112	119	125	132	139	145	--
26											114	121	129	136	143	150	157	--
27											123	131	139	146	154	162	170	1
28											133	141	149	157	166	174	182	--

[1/] Based on weighted regression: $V = -0.40972 + 0.0021198\ D^2H$. Standard error of estimate = 1.37 cubic feet or 5.81 percent of the mean volume.

[2/] 10-inch class includes trees 9.6- to 10.5-inch d.b.h.

[3/] 70-foot class includes trees 67.6 to 72.5 feet in height.

[4/] Number of trees; range of data for 167 trees enclosed by solid lines.

Table 2.--*Board-foot volumes (1-foot stump to 7-inch top, d.o.b.), International 1/4-inch scale, for white spruce, Kuskokwim River valley, Alaska*[1/]

D.b.h. (D)[2/]	Total height in feet (H)[3/]																Basis: trees measured[4/]
	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	
Inches																	*Number*
9	11	16	21	26	31	36	41	46	52	57	62						11
10	19	26	32	38	44	51	57	63	69	76	82						14
11	28	36	44	51	59	66	74	82	89	97	104						15
12		48	57	66	75	84	93	102	111	120	129	138					14
13		60	71	81	92	102	113	124	134	145	155	166					11
14		74	86	98	111	123	135	147	160	172	184	196					8
15			102	116	130	145	159	173	187	201	215	229	243	257			6
16			120	136	152	168	184	200	216	232	248	264	280	296	312		11
17				157	175	193	211	229	247	265	283	301	320	338	356	374	8
18					199	219	239	260	280	300	321	341	361	382	402	422	6
19					224	247	270	292	315	337	360	383	405	428	451	473	5
20					251	276	301	326	351	376	402	427	452	477	502	527	3
21					279	307	335	362	390	418	445	473	501	528	556	583	1
22								400	430	461	491	521	552	582	612	643	1
23								440	473	506	539	572	605	638	672	705	--
24								481	517	553	589	625	661	697	733	770	1
25										602	641	680	720	759	798	837	--
26										653	696	738	780	823	865	907	--
27										706	752	798	843	889	935	981	1
28										762	811	860	909	958	1007	1056	--

[1/] Based on weighted regression: $V = -24.62022 + 0.0125346\ D^2H$. Standard error of estimate = 21.43 board feet or 12.8 percent of the mean volume.
[2/] 10-inch class includes trees 9.6-to 10.5-inch d.b.h.
[3/] 70-foot class includes trees 67.6 to 72.5 feet in height.
[4/] Number of trees; range of data for 116 trees enclosed by solid lines.

Table 3.--*Board-foot volumes (1-foot stump to 7-inch top, d.o.b.) Scribner scale, for white spruce, Kuskokwin River valley, Alaska*[1/]

D.b.h. (*D*)[2/]	Total height in feet (*H*)[3/]																Basis: trees measured[4/]
	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	
Inches																	*Number*
9	3	7	12	16	21	26	30	35	39	44	48						11
10	10	16	21	27	33	38	44	49	55	61	66						14
11	19	25	32	39	46	52	59	66	73	79	86						15
12		36	44	52	60	68	76	84	92	100	108	116					14
13		47	56	66	75	84	94	103	113	122	132	141					11
14		59	70	81	92	103	113	124	135	146	157	168					8
15			84	97	109	122	135	147	160	172	185	197	210	222			6
16			100	114	128	143	157	171	186	200	214	228	243	257	271		11
17				133	149	165	181	197	213	229	246	262	278	294	310	326	8
18					170	188	206	224	243	261	279	297	315	333	351	369	6
19					193	213	233	253	274	294	314	334	354	374	394	415	5
20					217	239	262	284	306	329	351	373	396	418	440	462	3
21					242	267	291	316	341	365	390	414	439	464	488	513	1
22								350	377	404	431	458	485	512	539	566	1
23								385	414	444	473	503	532	562	591	621	--
24										486	518	550	582	614	646	679	1
25										529	564	599	634	669	704	739	--
26										575	613	650	688	726	764	801	--
27										622	663	704	744	785	826	867	1
28										671	715	759	803	847	890	934	--

[1/] Based on weighted regression: $V = -28.74136 + 0.0111643\ D^2H$. Standard error of estimate = 18.21 board feet or 12.7 percent of the mean volume.
[2/] 10-inch class includes trees 9.6- to 10.5-inch d.b.h.
[3/] 70-foot class includes trees 67.6 to 72.5 feet in height.
[4/] Number of trees; range of data for 116 trees enclosed by solid lines.

Table 4.--*Cubic-foot volume (1-foot stump to 4-inch top, d.o.b.) Smalian's formula, for paper birch and balsam poplar, Kuskokwim River valley, Alaska*[1/]

D.b.h. (D)[2/]	Total height in feet (H)[3/]												Basis: trees measured[4/]	
	30	35	40	45	50	55	60	65	70	75	80	85	Birch	Poplar
Inches													*Number*	
5	1.1	1.3	1.6	1.8	2.1	2.3	2.6	2.8	3.1				11	3
6	1.7	2.1	2.5	2.8	3.2	3.5	3.9	4.2	4.6				11	9
7	2.5	3.0	3.5	4.0	4.4	4.9	5.4	5.9	6.4	6.8			8	5
8	3.4	4.0	4.6	5.3	5.9	6.5	7.2	7.8	8.4	9.0	9.7	10.3	13	9
9		5.2	6.0	6.8	7.6	8.4	9.2	10.0	10.8	11.5	12.3	13.1	6	6
10		6.5	7.5	8.5	9.4	10.4	11.4	12.4	13.4	14.3	15.3	16.3	1	10
11			9.1	10.3	11.5	12.7	13.9	15.1	16.2	17.4	18.6	19.8	10	2
12				12.3	13.8	15.2	16.6	18.0	19.4	20.8	22.2	23.6	3	2
13				14.5	16.2	17.9	19.5	21.2	22.8	24.5	26.2	27.8	2	4
14				16.9	18.9	20.8	22.7	24.6	26.5	28.5	30.4	32.3	--	4
15					21.7	23.9	26.1	28.3	30.5	32.7	34.9	37.2	1	1
16					24.7	27.3	29.8	32.3	34.8	37.3	39.8	42.3	1	3
17						30.8	33.7	36.5	39.3	42.2	45.0	47.8	--	2
18							37.8	41.0	44.1	47.3	50.5	53.7	--	1
19							42.1	45.7	49.2	52.8	56.3	59.8	--	--

1/ Based on weighted regression: $V = -0.37551 + 0.0019624\ D^2H$. Standard error of estimate =0.98 cubic foot or 9.8 percent of the mean volume.

2/ 10-inch class includes trees 9.6- to 10.5-inch d.b.h.

3/ 70-foot class includes trees 67.6 to 72.5 feet in height.

4/ Number of trees; range of data for 67 paper birch and 61 balsam poplar enclosed by solid lines.